Learning Outcome Dependency on Contemporary ICT in the New Zealand Middle School Classroom

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ABSTRACT
Often studies of children's technology use in the classroom is internally focused and small scale. This study attempts a globalised exploratory overview of an entire New Zealand middle school to understand the technology usages across a range of curriculum and learning outcomes. Observations of the use of technology in the classroom during eight different lessons were conducted followed by structured-open-ended interviews. From our classroom observations and through teacher interviews, we have been able to identify three levels of the dependency of learning outcome on contemporary-ICT.

Author Keywords
Classroom technology, Children, Interactivity in learning, ICT use, Learning outcomes.

ACM Classification Keywords
H.5.0 General

General Terms
Human Factors

INTRODUCTION
It is often said, we live in very exciting times, this is clear in the technological advancements that have seen the traditional classroom transformed into a digital world with a wide range of interactive media that targets not specifically one learning style [9], but now seeks to include them all. With this in mind this paper seeks to understand contemporary technology or ICT use in a New Zealand middle school classroom with an eye to join Sims in his broadly cited 1998 call to arms. In this influential paper Sims states, "there remains much to learn about the impact of interactivity on learning within the context of computer-based applications" [27:630]. In 2011, 13 years after Sims, Tamin et al [30] argue that the debate about technology's role in education has still not been fully resolved, even after numerous studies at all levels of the education system globally that date as far back as the 1960's.

Observations of the use of technology in the classroom were conducted in 2010 in a Hamilton normal middle school during eight lessons. These observations sought to understand what technologies are being implemented in New Zealand classrooms and what learning outcomes these technologies were seeking to facilitate. It is believed that with this knowledge further studies may be designed, which fully explore the effectiveness of some or all of these contemporary technologies. All lessons observed incorporated a contemporary technology mix in varying proportions with the majority of the lessons incorporating the use of interactive whiteboard technology to assist in achieving the stated learning outcomes.

The goal of this broad spectrum investigation was to illustrate a globalised picture of the use of contemporary technology across a range of curricula in a publicly funded New Zealand middle school. The two focal questions in this study were: *what is the range of contemporary-ICT being used in a publicly funded New Zealand middle school?* and *what is the dependency of learning outcome on technology in a publicly funded New Zealand middle school?* This differs from other studies [5,7,10] which have focused on individual technologies or curricula and not necessarily in a New Zealand context. The New Zealand curriculum based lessons observed during this study covered a wide range of subject areas including maths, social science, dance, music and language classes. One of these class observations found the students using technology for reading comprehension assessment purposes (on-line assessment tool e-asTTle), while another class involved the teaching of students about the use of the technology for classroom use (Promethean board and iPod touch), with most other classes utilising the technology to support the learning within the various curricula.

This study discovered predominant use of what we will term *contemporary-ICT*; computing or ICT equipment such as interactive white boards, personal mobile devices, personal computers and mobile computers, as well as technologies that integrate with these. Technologies also common to this school included student access to

calculators, video and audio equipment for both creation and playback (ie. DVD and video playing and projection equipment as well as stereo or audio devices). Many of these aforementioned contemporary-ICT are able to be used in ways which are both similar to and extend on ICT previously used in the classroom. For example, computers and interactive whiteboards are able to replace audio, still-image and video presentation and projection equipment as well as chalk and dry erase marker boards, while personal mobile devices have shown the potential to supply students in this study with alternative methods to access analogue media such as dictionary and reference books.

BACKGROUND

The benefits of interactive media in the classroom and other learning environments are still being explored, with debate and contradictory research findings having arisen from differences in research methods, in the types of interactive media environments and even in defining interactivity [6,24,25,26,30]. Research by Sims [28] discusses the need for a better understanding of how interactivity can provide benefits to the learner. In his introduction to why this is necessary he explains that interaction is "intrinsic to successful, effective instructional practice as well as individual discovery" [28:158]. Moreno & Mayer [18] support Sims argument that interactivity may enhance learning under the right conditions, explaining that interactivity can motivate the learner to engage in learning, especially, in situations where new information is organized into knowledge structures that integrate with prior knowledge or learning. With issues of cognitive load and increased complexity "the challenge for designers is to create learning environments that will manifest the conditions for effective interaction" [29:101]. Sims suggests that there is a need to further understand what benefits the continued introduction of interactive media is having in the classroom, "the factors that impact on the effectiveness of the interactive learning experience are diverse, complex and dynamic, and therefore reinforce the importance of studying its characteristics" [29:88].

Engagement theory, developed by Kearsley and Shneiderman [12], emerged from the disciplines of psychology, education and computer science, and is the premise that "students must be meaningfully engaged in learning activities through interaction with others and worthwhile tasks" [12:20]. When students are engaged in learning, they are involved in a wide spectrum of cognitive processes including reasoning, problem solving, decision-making and evaluation. It can therefore be argued that by incorporating alternative technologies and pedagogies into these classrooms, learners' engagement will be enhanced. Engagement Theory has been used as a basis for building an understanding of e-learning, interactive distance education and a range of interactive learning environments. More recently O'Brien & Toms [21] defined user engagement with technology and provided a framework for future research in this area. Their framework included defining engagement as a quality of user experience, with four distinct stages involved in the process.

Beeland [7] discusses Interactive Whiteboards as having the potential to deliver instruction in a variety of ways and encourage student engagement by targeting multiple learning styles. Many of the contemporary technologies available for use within the classroom will likely also engage these learning styles. Visual learning through the use of text, graphics, animation and video. Auditory learning via the use of sounds and words being orally pronounced through speeches, poems, and this combined with the act of listening. And finally kinesthetic or tactile learning because of the ability for students to physically interact with an interactive board or other learning tool. In addition, information can be displayed from software and the Internet, along with information being typed using a computer keyboard or handwritten directly onto a device using a wide range of colours and resource material that can be saved for future use by individual students or the entire class.

It is clear, however, that simply using or installing technology in a classroom will not prove the solution to meeting the needs of all students' learning. It has been noted in several studies that for interactive technologies to be truly effective a teacher's pedagogies need to change to take full advantage of the interactive learning environment, rather than simply reinforcing traditional pedagogies in a new media [11,20]. Leung [14] argues that the teacher must design the interactive experience by managing the relationship between the learners, the educators and the technology in a meaningful way. This is supported by Sims who stated "if interactive learning environments can be created where the learner takes on a more participatory role and becomes an active player in a performance, then the interactive constructs may better match the expectations of the user" [29:101]. Therefore, if teachers and students use interactivity and digital technology effectively then it could be beneficial to learning.

METHOD

This research took a multi-faceted approach to understanding technology use in the New Zealand middle school classroom. It firstly involved observing children during classes that included a technology component in their lesson. Students were not questioned or interacted with by the researchers. Two researchers at any one time conducted the observations, recording their observations via pen and paper, no audio or visual recordings were taken during the observations. Illustrations of each environment were recorded as well as timed interval running record observations as described by [15,22,23].

The data recorded included information regarding what type of technology was being used, what input devices,

screen size, and software were involved, where the lessons were being conducted, how long a lesson lasted and what guidance the teacher provided in using this technology. Data regarding how the children interacted with the technology was also collected.

Interviews conducted as the second aspect of the research sought to gain insight about the learning outcomes and how, or if, these were achieved with the use of these technologies. These interviews took place after each of the lessons using a brief structured, open-ended interview with the teacher. The teachers were asked to consider the technology they used during the observed lesson, if these technologies used have any perceived weaknesses and what other methods the teachers might otherwise use to deliver the same learning outcomes.

The questions asked were as follows:

1. What are the intended learning outcomes of this class?
2. Have you used this resource for teaching this learning outcome/lesson before?
3. How did this resource assist in meeting the learning outcomes?
4. Can you identify any shortcomings of this resource which prohibited fully meeting your learning outcomes?
5. Is this the only method that will be implemented for teaching these learning outcomes?
   Can you please expand?
6. What other resources could be utilised to achieve these learning outcomes?
   (consider traditional / analogue methods and contemporary technologies
   - the teacher should not feel compelled to consider only computing technology)
7. Do you perceive the resource you used in this class to be better/worse/equally successful than one of the other resources you mentioned in the previous question?
   How or why?

Environment

The school recruited for this study was a restricted composite school that comprises years seven to nine in the New Zealand school system, with students predominantly falling in a band of 10 to 14 years of age. This school was chosen for a number of reasons as outlined here. The school's role of 663 students has a gender mix of 51% male to 49% female students giving an unbiased gender mix in classes, allowing for equal opportunity observation of children's classroom based technology use. As a normal school, it is common for this school to work closely with the education programmes of the University of Waikato School of Education, thus, children are familiar with researchers and student teachers in the classroom. This school is a decile 9 middle school according to the New Zealand decile school rating system [16]. A decile 1 rating indicates a high proportion of students from low socio-economic communities, while a rating of 10 indicates a low proportion of students from low socio-economic communities.

This school is active in its technology use and the access to technology in the classroom is intended to assist in prioritising enhanced learning opportunities for the students. This school began installing Interactive Whiteboards (IWB) across classrooms towards the end of 2007 with the remainder of the schools 22 classrooms fully outfitted with IWB (Promethean Interactive Whiteboards) in 2008. During 2009 and 2010 the remaining 6 specialist teaching spaces were fitted with IWB. Staff received professional development support and training in staged beginner, middle and advanced phases in time for installation in their teaching space. The iPod touch was introduced in 2010 after a large community meeting and staff development in 2009. At the time of investigation approximately 200+ student-owned-iPods were accessing the schools wireless network on a regular basis. One full class of composite Year 8 and 9 students were pilot studied with school purchased iPod touch's in 2010 to fully investigate the potential of this technology. Personal voting devices (Acti-vote systems) are also commonly used with the IWB with 2 full class sets available within the school. The school also has a single computer suite with 30 Macintosh computers and 4 C.O.W's (computers on wheels) with 18 Macintosh laptops per C.O.W. Each teacher also has a laptop supplied for the purposes of their teaching. 2009 saw the first year of electronic assessment using PAT on-line (electronic Progressive Achievement Tests) for maths and comprehension assessment and in 2010 e-asTTle was in use instead of PAT on-line.

For each lesson observed, the rooms were illuminated with natural light and supplemented with electrical light bulbs or fluorescent tubes.

CLASSROOM OBSERVATIONS

Lesson One (Maths)

In some instances there was minimal interaction or multimedia use of the IWB. Several classes, most notably Lesson One, used the IWB at the beginning of the lesson to introduce the learning outcomes for the session. Other classes also used it as a means of introduction to the ideas explored in that lesson. Lesson One did not use the IWB after this. This use of technology provides little advantage over more traditional teaching media such as a whiteboard or blackboard. When interviewed, the teacher of this lesson believed that the way he had utilised the technology was equally successful as other media they could use, commenting "[the lesson] would work fine without it". The teacher felt that the same learning outcomes could be achieved through the use of iPod touches, laptops or pen and paper with a workbook.

Lesson Two (Literacy Assessment)

The use of technology for literacy comprehension assessment was observed in one class where a reading comprehension test was being conducted. The assessment tool being used was the online e-asTTle (Assessment Tools for Teaching and Learning), developed for the New Zealand Ministry of Education for assessing literacy and numeracy [1]. The students used a combination of 24 iMacs and six Macbook laptops to access the e-asTTle testing website using Firefox. Students were allocated one machine each. As this was the first time the students had used this tool, the beginning of the lesson had the teacher guiding the students though the initial set up and registration steps required to allow the students to begin the test. The students were required to log in to the website and navigate the test, answering the multi-choice questions with radio buttons. When explaining aspects of how the test worked or what needed to be done next the teacher frequently described the process to be followed using paper metaphors. Most students would have completed similar tests previously using a pen and paper-based multi-choice answer sheet. Throughout the set-up period, instructional period and testing period of the lesson it was observed that the students' confidence and competency with technology varied greatly. The teacher acknowledged that this was the first time the test had been administered at the school with this technology. According to the teacher, the technology had some "issues", but they acknowledged that the tool also made the grading process smoother.

Lesson Three & Lesson Four (Two different Language Classes)

Two language based classes were observed using the IWBs, while both used the same technology in the lesson, they were used in slightly different ways. In one class the board was used for three different types of activities, firstly it was used passively, for the students to watch a video presentation and with the teacher discussing the content as it went. The teacher then used the board to play a web-based game with the students, where they took turns interacting with content on the board using the pen. In the third part of the lesson students wrote on their own answer sheets and the teacher filled in the answers on the same sheet presented on the IWB. The second language lesson also had the students using the pen to interact with content on the whiteboard, except the students used the pen to drag words around the board and translate them. The board was also used to give students the pronunciation of words so that they could repeat them. The second half of this lesson had the IWB displaying questions that the students answered in pairs using a pen and paper. The teacher of this lesson felt that a shortcoming was that there was not enough time for every student to have a turn interacting with the board, but felt that it was very useful that students could go back in their own time and listen to audio recordings. The teacher believed the technology helped to make the lesson interactive and interesting.

Lesson Five (Dance/Music)

In a music and dance class that was observed, the IWB was used for both its ability to convey audio-visual material as well as interact with the board to determine what dance they would be doing next, press play on the music or pull names out of the "hat". The board was also used to display the words of the song that they were singing. The teacher of this lesson felt that despite having used this technology last year to achieve this learning outcome, the students who were seeing this technology for the first time were just as effective at using it as he was. They also felt that even though this technology was equally as effective as other resources, it made it easy to change the music and it was "right there" and stimulating for the students.

Lesson Six (Technology Introduction)

One of the lessons observed was dedicated to familiarising students with the use of the IWB, the pen and personal voting device at the start of the school year. The purpose of the lesson was to build the students' confidence with the board so that the technology could easily be integrated into other classes and lessons. For instruction and experience on use of the IWB pen, students played board-game style games on the IWB using the pen, taking turns, while the other class members wrote in their books. The second part of the lesson involved the use of the personal voting devices. It was the first time students had used these and the voting revolved around English and math based questions and the voting and answers being discussed. Students were very curios about the technology and keen to participate, with many students observed sitting on the edge of their seat. When students were given the personal voting device they examined them carefully feeling buttons and wanting to turn them on; one student was even observed as assessing the weight of the handheld device. There were initial connectivity issues with the personal voting devices registering, but this was rectified. Having a lesson dedicated to familiarising students with the technology is supported by Sims [27] who explains that in an interactive experience, if the situation is alien to the user, then much of their attention will be put into deconstructing the content from the interface. Some of this was evident in the way in which some students interacted with the e-asTTle software described in Lesson Two. If this is the case then it could be assumed that the learning process may be de-emphasised or interrupted affecting the ability of the user to experience deep learning. The benefits of this technology literacy type class will therefore be seen as potentially greater teaching efficiency in other classes.

Lesson Seven (Social Science) & Lesson Eight (Maths)

In contrast, other lessons utilised a very wide range of technologies for different purposes. The two observed lessons that embraced a broad range of technology both did so in a similar way. Both lessons began with activities with the IWB as the predominant technology; however, neither

of these instances fully utilised the abilities of the board. Both lessons had the board display a page of text for the students to read, the class discussed what was presented on the board. In Lesson Eight the class group also answered questions displayed on the board individually in books, then progressed to using the IWB as a class group. This classes' interaction around the IWB involved students working out equations on the board with the pen.

The two classes spent the second portion of their lessons using laptops and iPod touches to achieve the learning outcomes. Students worked in groups of three, meaning there were approximately ten laptops being used in each classroom. The reason for this was explained by the teacher as being mostly to do with the capabilities of the schools server having the number of laptops being used in the same location.

The small groups collaborated and interacted socially in an effective manor with student participants frequently sharing control of the mouse and keyboard. It was often noted that student participants who were not controlling the laptop utilised an iPod touch to support the learning through introduction of alternative search and problem solving tools such as dictionaries and thesauruses or access to the internet for relevant information. There were approximately 10 iPod touch devices in each of these two classrooms and students were encouraged by the teacher to use these alongside the laptops. During the interviews, teachers often mentioned that the iPod touch could be used to help students meet the learning outcomes of many of the lessons that incorporated media other than the IWB.

The software being used on the laptops varied with one class using a program called "Comic Life" supported by web-based resources such as web browsers, google image search and watching youtube videos. The other group used three websites that were maths based games, 'Count On - Who Wants to be a Mathonaire', 'Maths Zone - Interactive maths: Word problems' and 'Maths Starter of the Day' [2,3,4].

The teachers of both of these lessons acknowledged that other media can and would be used to achieve similar learning but felt that the contemporary technology being used was better than other more traditional means that were available to them.

TEACHERS' INTERVIEWS

The learning outcomes of the eight lessons observed were somewhat varied, and the range of pedagogies engaged was diverse, thus, a broad range of responses were given by the teachers. Learning covered a wide range of subject areas from critical thinking and ICT problem solving strategies to shared dance. This allows insight into where technologies are most effectively used for meeting certain learning outcomes and what could potentially be done differently, or how pedagogies may need to change to better meet other learning outcomes.

The intended learning outcomes of the classes observed ranged from technology centred goals such as helping students to become confident with Interactive Whiteboard technology, "using computers to display information" and "ICT problem solving strategies" through to objectives such as teaching critical thinking and teaching basic second language vocabulary which are independent of a specific media. One observed lesson was of a reading comprehension test being administered online for the first time within the school. This lesson was the only lesson observed where the learning outcome being implemented had not previously been achieved using the technology being observed. When learning outcomes had previously been taught using the observed technology, the lessons had been conducted with a different set of students. This was because the observations were conducted near the beginning of the school year.

The contemporary technology resources helped to assist in meeting the learning outcomes in a variety of ways. The main benefits fell into three categories; the resource worked for a range of abilities, the resource was fun and interesting for students because of interaction and collaboration, and the resource was accessible and available outside and inside the classroom. Teachers felt that students benefited by being able to access the material at home and that students were able to relate to the material at different levels and interact with the material at multiple intervals and varied paces.

In contrast, the shortcomings of the technology identified by teachers, that inhibited the learning outcomes being met, predominantly fell into 4 categories; environment, presentation, resources and technical. Shortcomings associated with the environment were to do with the lack of appropriate conditions for viewing the IWB screens. Window light was discussed by the teachers as also causing issues in a number of situations with colour reproduction or glare on the IWB. A further shortcoming was observed by the researchers in the shape of classrooms having been designed for pre-IWB classroom style interactions. This was evident in walls or pillars impeding students view of IWB's from their desk or other learning spaces in some rooms.

Issues of presentation raised by the teachers were predominantly associated with the text size, scrolling in some web interfaces and the buttons available within the IWB interface. The availability of quality and relevant resources for the IWB and the iPod touch, especially New Zealand appropriate resources, was also raised as a shortcoming of the technology. Learnability of the technology by the teachers was also said to be a factor that hindered the use of the technology and software at times.

The most common technical issue discussed during the interviews were related to the capabilities of the schools' server to cope with more than 10 laptops in a classroom at once which resulted in approximately one laptop per three children for most lessons.

For most teachers the technology that they were observed using for the lesson is not the only method that the teachers were familiar with or might implement for teaching these particular learning outcomes. Teachers who stated they would use other methods would either use more traditional media or would use different digital or audio-visual technology to achieve the same learning outcomes. Only two teachers said that this technology observed was the only technology they would use to achieve this learning outcome. Most learning outcomes could be met using more traditional classroom media, such as pen & paper, books and whiteboards, but most teachers did consider that the contemporary-ICT they were using helped to meet the desired learning outcomes better than other potential media. The improvement in meeting the learning outcomes was often considered to be a result of increased interactivity and engagement.

DISCUSSION

It is often argued that use of technology in the classroom is not a panacea and must be used to enhance learning outcomes through sound pedagogy. In fact, Clark's influential 1983 paper *Reconsidering research on learning from media* suggests that "media do not influence learning under any conditions" [8:445] Clark argues that studies that have shown benefit through a particular media have in fact shown benefit through a resource used or pedagogy implemented using that media. Kozma [13] argues that a re-framing of Clarks' argument is required and that researchers and designers must consider not "do but will media influence learning" [13:2]. Kozma continues "I believe that if we move from 'Do media influence learning?' to 'In what ways can we use the capabilities of media to influence learning for particular students, tasks, and situations?' we will both advance the development of our field and contribute to the restructuring of schools and the improvement of education and training" [13:23].

This is supported by Moseley et al [19] who suggests their study implies that attainment levels can be improved when ICT is used, to support literacy and numeracy education. Moseley et al [19] also indicated that teachers' professional development was significant in assisting teachers to identify pedagogical reasons for when, when not and how to use ICT to achieve learning outcomes. This very need to carefully consider the effectiveness of a technology to meet a learning outcome is evident in our observations and the results of our interviews.

Moersch (1995) developed a seven level framework for measuring technology implementation in the classroom, to encourage authentic use of technology, shifting the focus from teacher-centred- to learner-centred-instruction. This framework helps to develop understanding of how technology can be used in the classroom to extend students' understanding of concepts, processes and tools involved in using these technology. Our study did not look at how these contemporary-ICT helped in the delivery of learning outcomes. From the observations made during our study the classes were using technology at levels two through to six, *exploration* ("Technology-based tools serve as a supplement to existing instructional program" [17:42]) to *refinement* ("Technology is perceived as a process, product..., and tool, to help solve authentic problems related to an identified real-world problem or issue." [17:42]) on Moersch's framework, with most working at the *infusion* and *integration* stages of levels *three* and *four*.

From our classroom observations and through the teacher interviews, we have been able to identify three levels of dependency of learning outcome on technology. We have labeled these three categories; low-, medium- and high-dependency. Dependency on contemporary-ICT is considered from the perspective of the student as the user. Dependency is considered a measure of the degree to which the child's learning outcomes are subject to their interaction with the technology.

This observation that there are three somewhat distinct categories of technology dependency is explained by Anderson [6] who shows that no single media for the delivery of educational material can be said to be superior to all other media. Anderson's equivalency theory implies that "an instructional designer can substitute one type of interaction for one of the others (at the same level) with little loss in educational effectiveness" [6:5]. Anderson's equivalency theory also recognises a user's ability to substitute one form of interactivity for another.

The first category of technology integration is *low-dependency* of contemporary-ICT on learning outcomes. This was seen in classes where the use of contemporary-ICT provided minimal advantage to the student over traditional analogue classroom media or where a traditional or analogue resource could have been used equally successfully to meet the learning outcomes for the student. This was observed in classrooms where the Interactive White Board was used by the teacher simply as a method to display information, for example Lesson One above. This category could also include instances where the board was used to display audio visual material through the control of the teacher. It is arguable that these instances of technology use could equally well have been achieved with analogue technology such as the pen and whiteboard, slide projector or video or digital video presentation. Interaction with ICT for the benefit of the learning outcomes on the behalf of the student was low in these instances.

The second level of integration is one of *medium-dependency* where students interact with contemporary-ICT to achieve learning outcomes, but other media could be used successfully to achieve similar core learning outcomes. In this category the interaction created by the technology being used increases the engagement of the students, possibly through the 'novelty factor' that it creates. This was evident in Lessons Three and Four where the IWB was used in a creative manor to introduce collaborative means for the students to interact with these resources. While other technology could have been used in these scenarios, this technology was used in an appropriate manor and was effective in engaging a range of learning styles in a large group setting.

In the third category there is a *high-dependency* on the contemporary-ICT with a close link between the learning outcomes of the lesson and the ways in which technology is integrated and utilised by both the teacher and the students. In these lessons it was observed that students frequently used multiple media simultaneously, such as Lessons Seven and Eight, or the technology was essential to achieving the intended primary learning outcome of the lesson. These levels of dependency also seem to relate to how strongly the technology was involved in delivery and execution of the lesson.

From our observations there was a reasonably even spread of lessons between the three levels of dependency that we have outlined. The overview that this research gained will prove useful in developing future studies regarding ICT in the classroom as well as provide insights into the breadth of ICT use in the modern classroom. This helps to provide reason for continued research investigating ways that technology can enhance or hinder children's learning and emphasises the need for designers of children's technology to comprehensively understand the environment in which their resources will be used.

FUTURE RESEARCH

While this study was exploratory in nature and sought to recruit only a single school, it has been important in addressing the question; *what contemporary ICT is being used in New Zealand middle schools?* However, because this study recruited a school within a specific decile band it could be argued that it in-fact addressed the more specific question; *what contemporary ICT is being used in New Zealand middle schools* ***in the high decile bands****?* Therefore, further studies are required that provide a comparison of learning outcomes to perceived benefits of and dependency on contemporary ICT. Thus asking the question; *is this varied technology mix and full school integration common across socio-economic and therefore decile bands in New Zealand primary and middle school classrooms?* This research team also proposes studies which further implement investigations with individual technology's across curricular to assess their potential for both engagement and dependency.

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